컴퓨터그래픽스

2017학년 1학기

김준호

국민대학교 소프트웨어학부

Course Instructor

- Name: 김준호 (Junho Kim)
- Research interests
  - Computer Graphics
  - Computer Visions
  - Mixed Reality
- Expertise
  - 3D reconstruction & understanding
  - Mobile graphics & augmented reality
- Contact Info.
  - ☎: 02-910-4826
  - E-mail: junho@kookmin.ac.kr

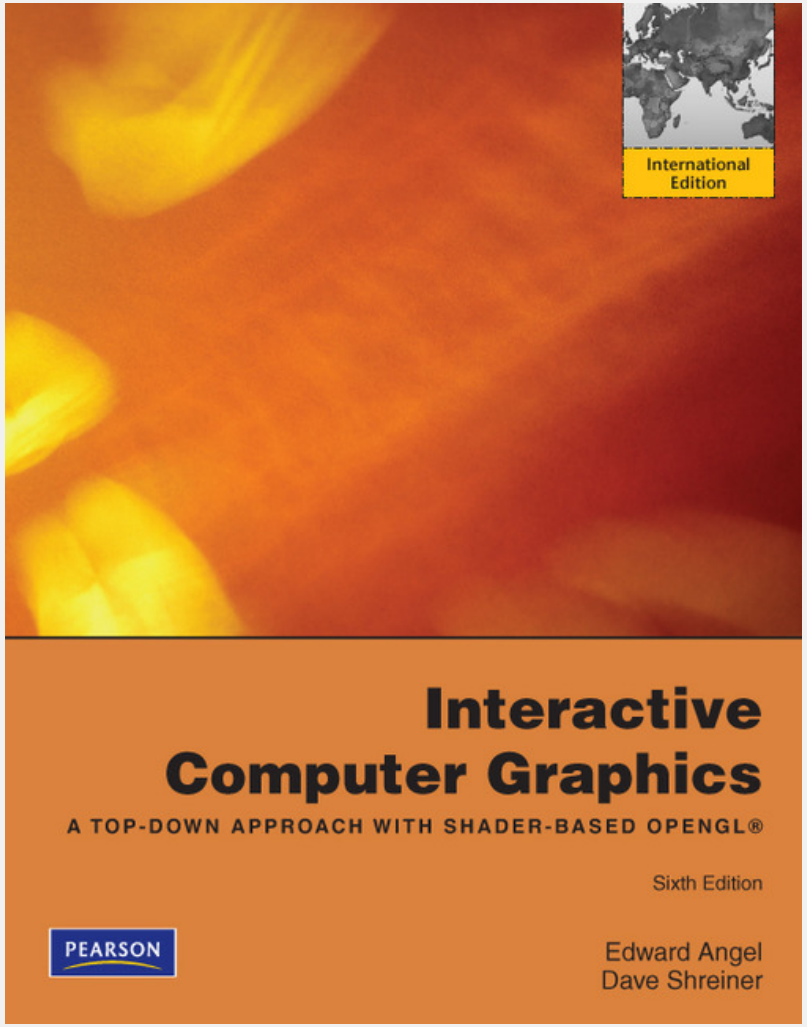
Teaching Assistant

- 이진우 (Jinwoo Lee)
  - 비주얼 컴퓨팅 연구실
  - 7호관 614호
  - ☎: 02-910-5564
  - E-mail: sosuminjok@gmail.com

- 김희태 (Heetae Kim)
  - 비주얼 컴퓨팅 연구실
  - 7호관 614호
  - ☎: 02-910-5564
  - E-mail: htkim10423@gmail.com

Textbook

- Interactive Computer Graphics: A Top-Down Approach with Shader-based OpenGL (6/E), by Edward Angel and Dave Shreiner.



Course Description

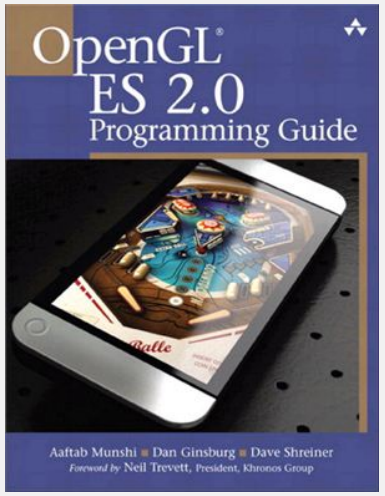
- Lectures hours
  - Tue. 15:00 ~ 16:15 Lecture
  - Thu. 18:00 ~ 19:15 Lecture & Lab.
- Course evaluation (tentative)
  - Midterm: 30%
  - Final: 30%
  - Assignments & Team Projects: 30%
    - Assignment: 1-2 students can be a team for assignments
    - Project: >= 4 students can be a team for a project.
      - You can select a topic from the project list which I suggest.
      - (*You can get extra credits when you provide excellent results in your projects)
  - Attendance: 10% (incl., attitude)

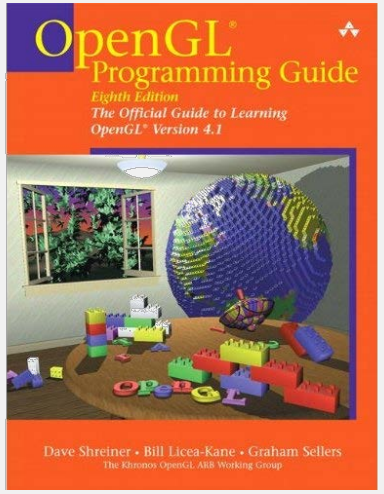
Course Description

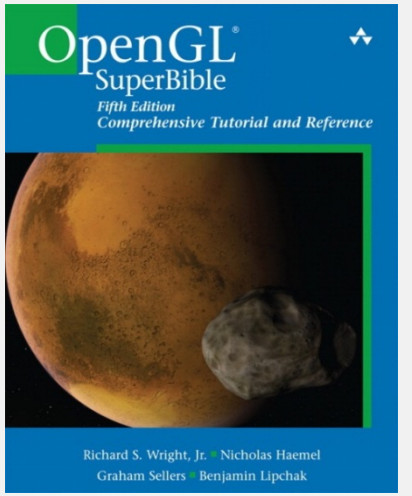
- Objective
  - To learn the basic theories of computer graphics
    - Transformations, Viewing, Interaction
    - Modeling, Rendering, Animation
    - Fragments, Buffers, Buffer Objects
  - To understand the interactive graphics techniques with
    - Shader-based OpenGL: programmable rendering pipeline
    - Non shader-based OpenGL: fixed rendering pipeline
  - To know about advanced topics in computer graphics
    - Mobile graphics basics: OpenGL ES 1.x & 2.x

References

- Useful books
  - OpenGL ES 2.0 Programming Guide
    - http://opengles-book.com/
    - Several figures in this slides come from this book
  - OpenGL Programming Guide (a.k.a., OpenGL Redbook)
    - Available in online: http://glprogramming.com/red/
    - Several figures in this slides come from this book
  - OpenGL Superbible
    - http://www.starstonesoftware.com/OpenGL/







References

- Useful reference sites
  - OpenGL generals: http://www.opengl.org
  - OpenGL ES: http://www.khronos.org
  - WebGL: http://www.chromeexperiments.com/webgl

- Useful OpenGL tutorial sites
  - NeHe OpenGL Tutorials: http://nehe.gamedev.net/
  - Lighthouse3D OpenGL Tutorials: http://www.lighthouse3d.com/opengl/tutorials.shtml
  - Song Ho Ahn's OpenGL Tutorial : http://www.songho.ca/opengl/index.html

Some Tips

- Please, make questions in the lectures
  - Q & A could be ok in Korean.
- Materials related to our textbook is available at the following author's homepage
  - http://www.cs.unm.edu/~angel/BOOK/INTERACTIVE_COMPUTER_GRAPHICS/SIXTH_EDITION/
  - I strongly recommend you to print out the PPT slides therein and bind them.
- Use Google & wikipedia to get further information
  - Google: www.google.com
  - Wikipedia: www.wikipedia.org

Some Tips

- Please, make questions in the lectures
  - Q & A could be ok in Korean.
- Materials related to our textbook is available
  - http://www.cs.unm.edu/~angel/BOOK/INTERAC
  - I strongly recommend you to print out the PPT sl
- Use Google & wikipedia to get further inform
  - Google: www.google.com
  - Wikipedia: www.wikipedia.org

- **걱정하지 마세요! 매우 쉽습니다.**
  - 단, 수업을 잘 따라오고 있으실 경우…

- **Computer Graphics**
- OpenGL & OpenGL ES

Introduction

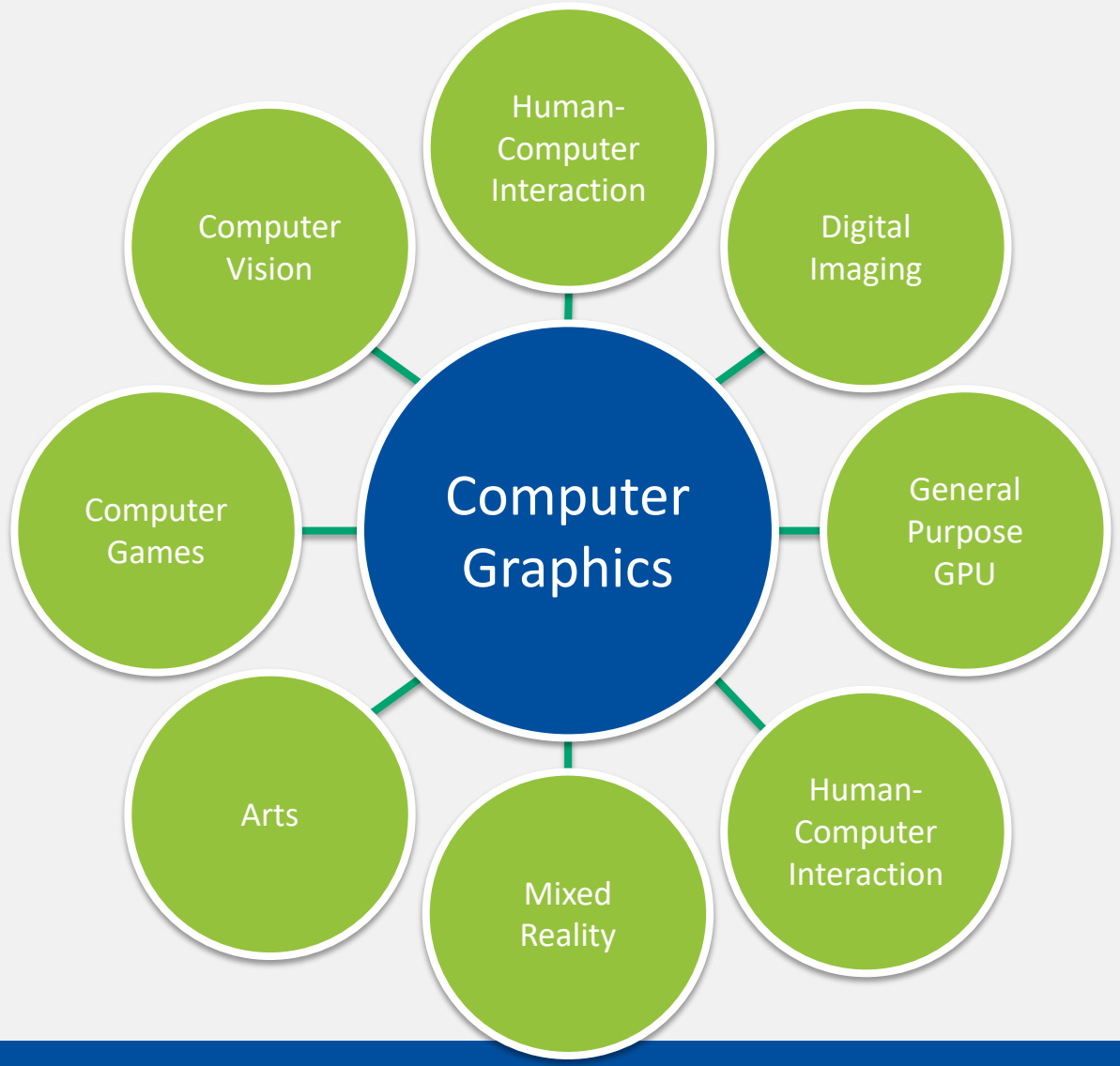
Introduction to Computer Graphics

- Computer Graphics is …
  - The representation and manipulation of pictorial data by a computer [from wikipedia.org]

[Toy story – offline graphics]

[Skyrim – interactive graphics]

Introduction to Computer Graphics



Introduction to Computer Graphics

- Computer Graphics + Computer Vision
  - Panoramic photos
    - Panorama mode (iOS6 above)
    - PhotoSphere (Android 4.2 above)
    - cf) QuickTime™ VR, Apple Inc. in 1995
      - Image-based rendering
      - Image stitching technology
  - 3D maps
    - Apple Maps (iOS6 above)
    - Google Maps 3D (app)
    - cf) C3 Technology, acute3D
      - Multiple view geometry
      - Photogrammetry technology

Introduction to Computer Graphics

- Computer Graphics + Digital imaging
  - New types of digital cameras
    - Lytro: Shoot now, focus later
      - Capturing light-field with camera array
      - Article in NY Times, Episode with Steve Jobs

(video, youtube)

Introduction to Computer Graphics

- Computer Graphics + Mixed Reality
  - Natural feature tracking
    - QR 코드와 같이 특별한 형식의 마커가 아닌 일반 영상을 마커로 인식
    - e.g.) Qualcomm® Vuforia™
  - SLAM-based approach
    - 실시간으로 주변환경에 대한 지도를 작성고, 지도 내의 현재 위치를 인식
    - e.g.) MS KinectFusion, MS MobileFusion, PTAM, Google Project Tango

(video, youtube)

(video, youtube)

Introduction to Computer Graphics

- Computer Graphics + Computer Games
  - Physics engines
    - 복잡한 물리 연산을 실시간으로 계산
    - 영화와 같은 연출 가능
    - E.g.) nVidia PhysX engine
  - Pre-computed radiance transfer
    - 실시간 렌더링 계산이 용이하도록,
      오프라인으로 미리 처리
  - Stylized rendering

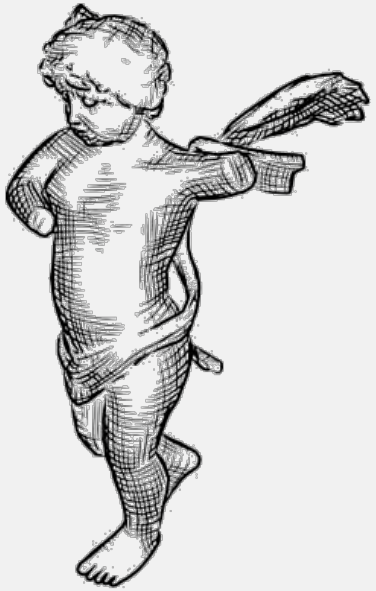
(video, youtube)

(video, youtube)

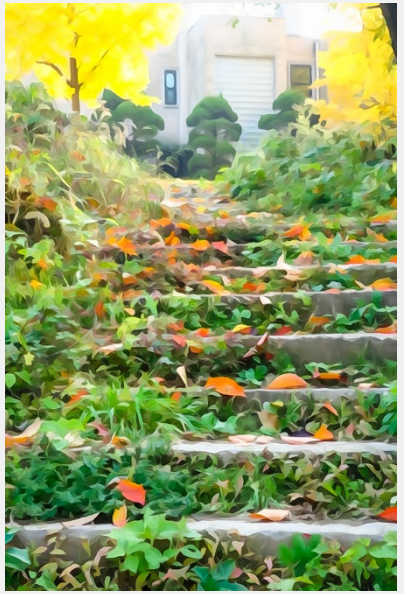
Introduction to Computer Graphics

- Computer Graphics + Arts
  - Stylized rendering
    - 사진과 같은 사실적 렌더링 결과가 아닌,
      화가가 그린 듯 스타일이 살아 있는 렌더링

Madame Palmyre with Her Dog
– Henri de Toulouse-Lautrec



Stylized rendering of Cupid
[Herzmann and Zorin 2000]

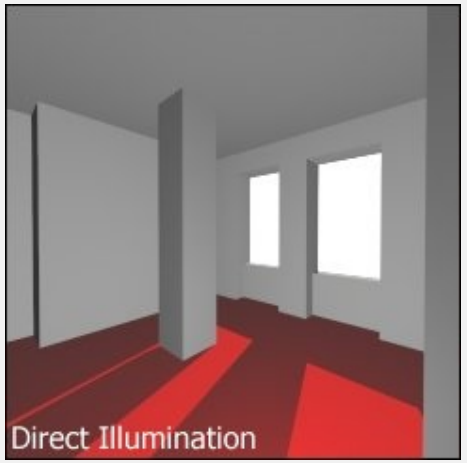


Sony RX-100 Paintly rendering
http://panboy.tistory.com

Principles of Computer graphics

- Illumination
  - Global v.s. Local
    - Time – Quality tradeoff

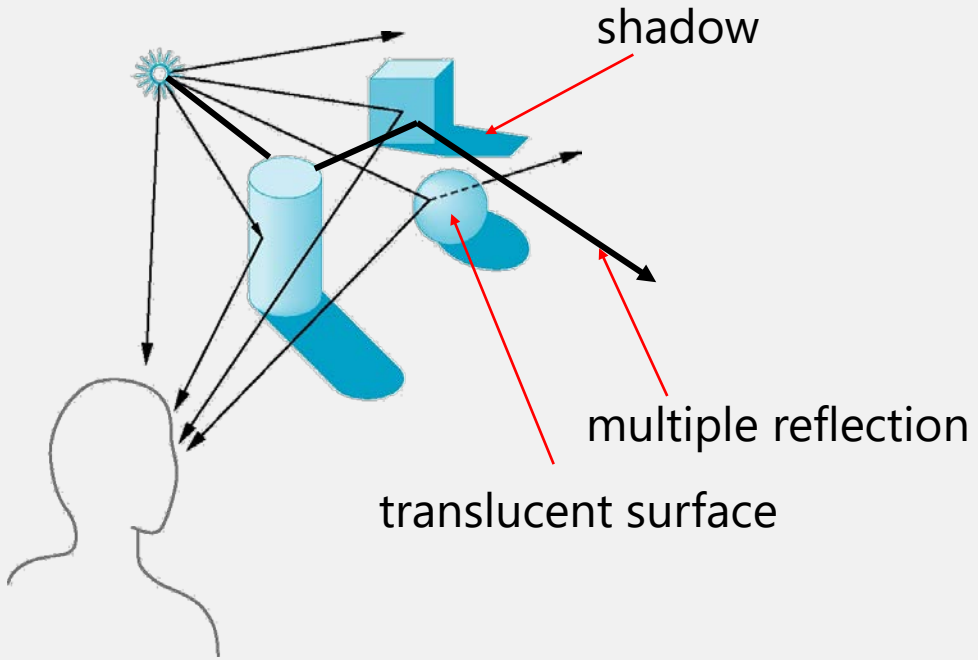
Global illumination
- Off-line graphics
- High quality
- E.g.) Animations, Cinematic effects

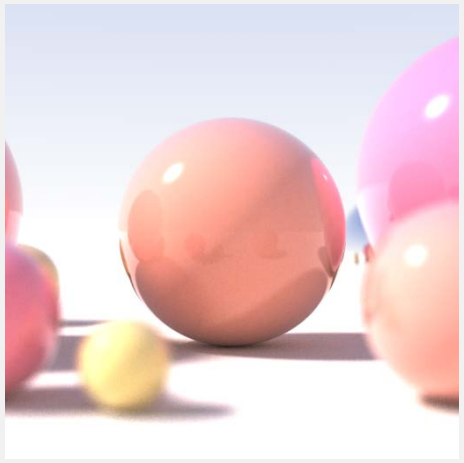


Local illumination
- Interactive graphics
- Low quality
- E.g.) Mobile UI, Games

Global Illumination

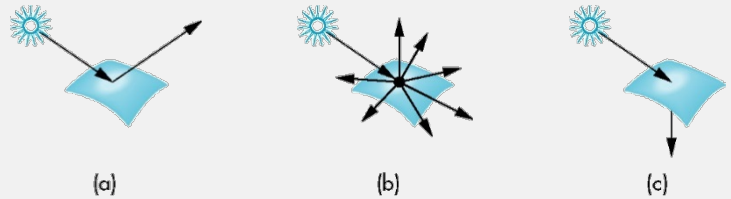
- Non-real-time in general
  - Rendering equation
    - Radiosity, Ray tracing
- Considering global light effects
  - Direct illumination
  - Indirect illumination

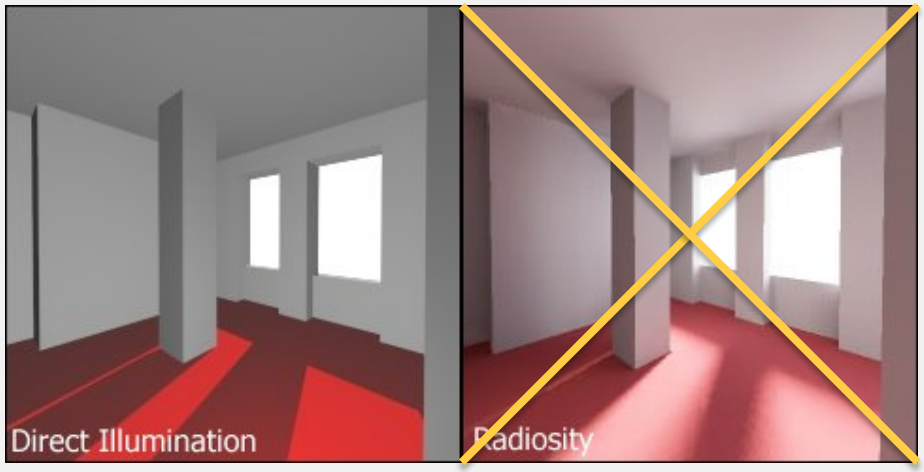




Local Illumination

- Real-time in general
  - Phong reflection model
- Considering local effects only → H/W friendly
  - Direct illumination
  - ~~Indirect illumination~~





Interactive Computer Graphics

- Real-time, real-time, real-time!!!
- H/W accelerated graphics
  - GPU
  - OpenGL, OpenGL ES, DirectX
- Interaction should be properly handled
  - Mouse/Touch interactions

- Computer Graphics
- **OpenGL & OpenGL ES**

Introduction

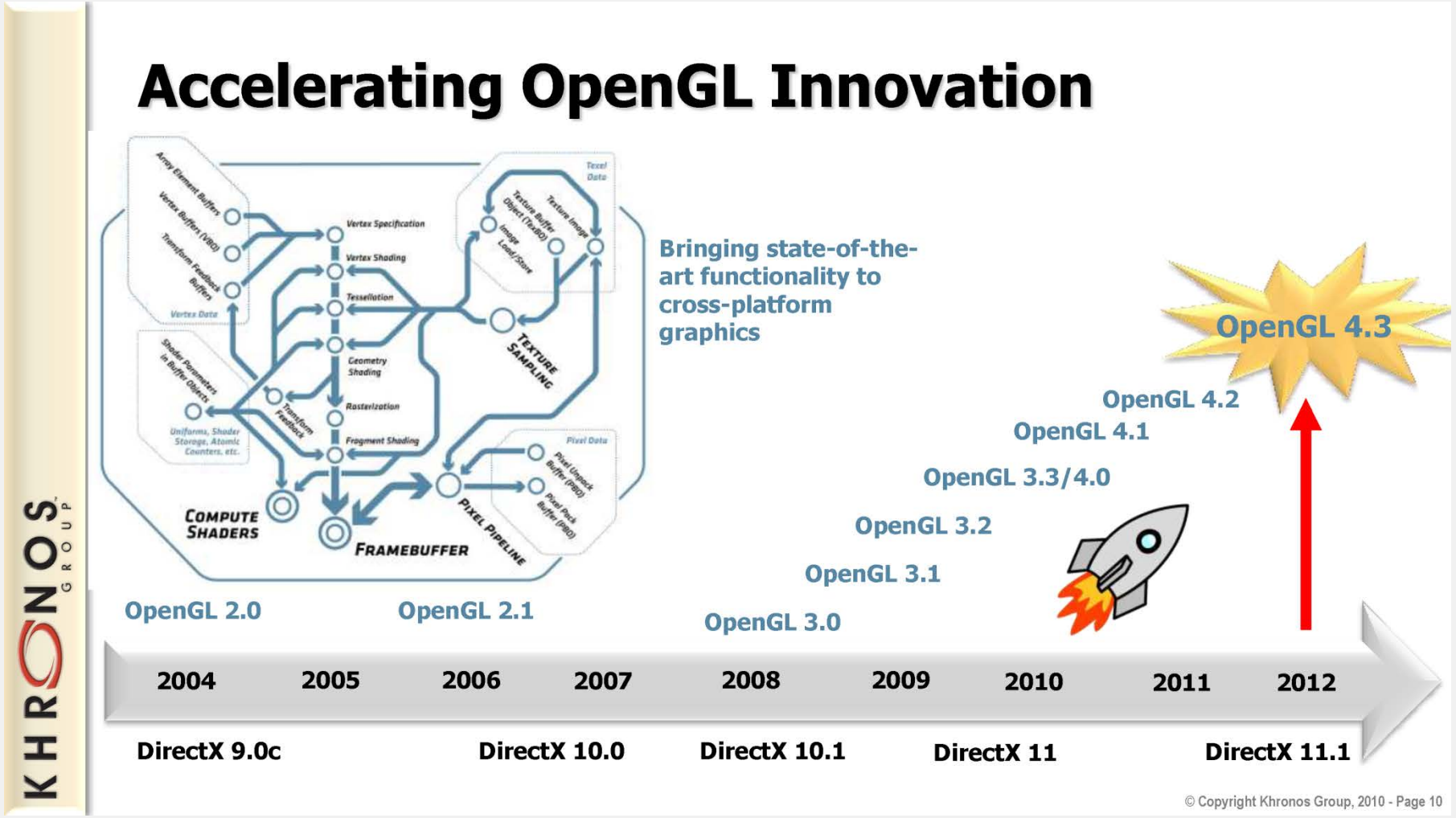
OpenGL

- ~ 1991
  - IRIS GL: a proprietary graphics API created by Silicon Graphics (SGI)

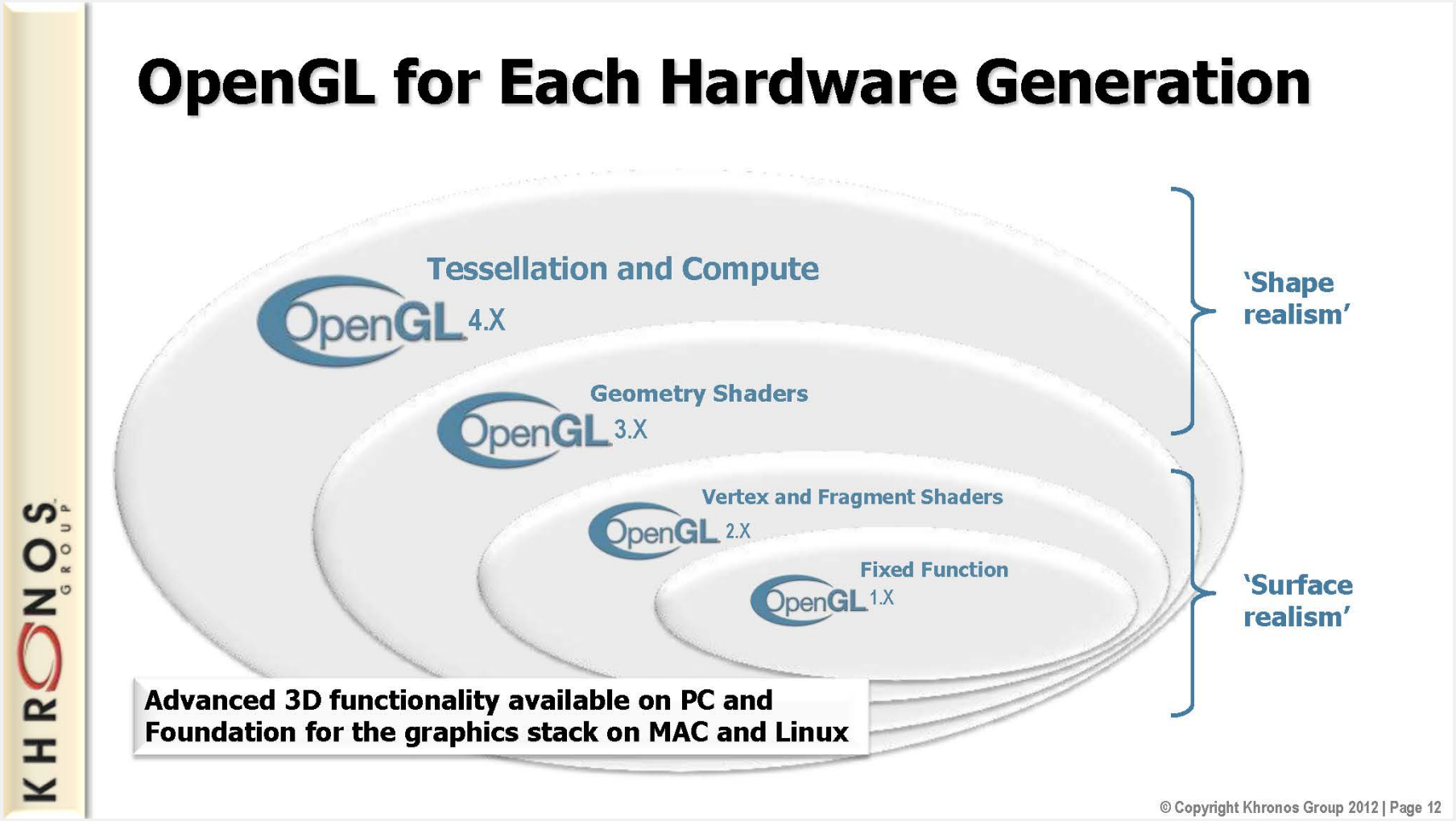
- OpenGL
  - Released in Jan. 1992
  - Procedural H/W accelerated 3D graphics
  - Maintainance
    - Maintained by OpenGL Architectural Review Board (OpenGL ARB)
    - Now, maintained by Khronos Group (2006 ~ Now)

- Strong competitor
  - Microsoft Direct3D (1998 ~ now)

History of OpenGL



History of OpenGL – Summary

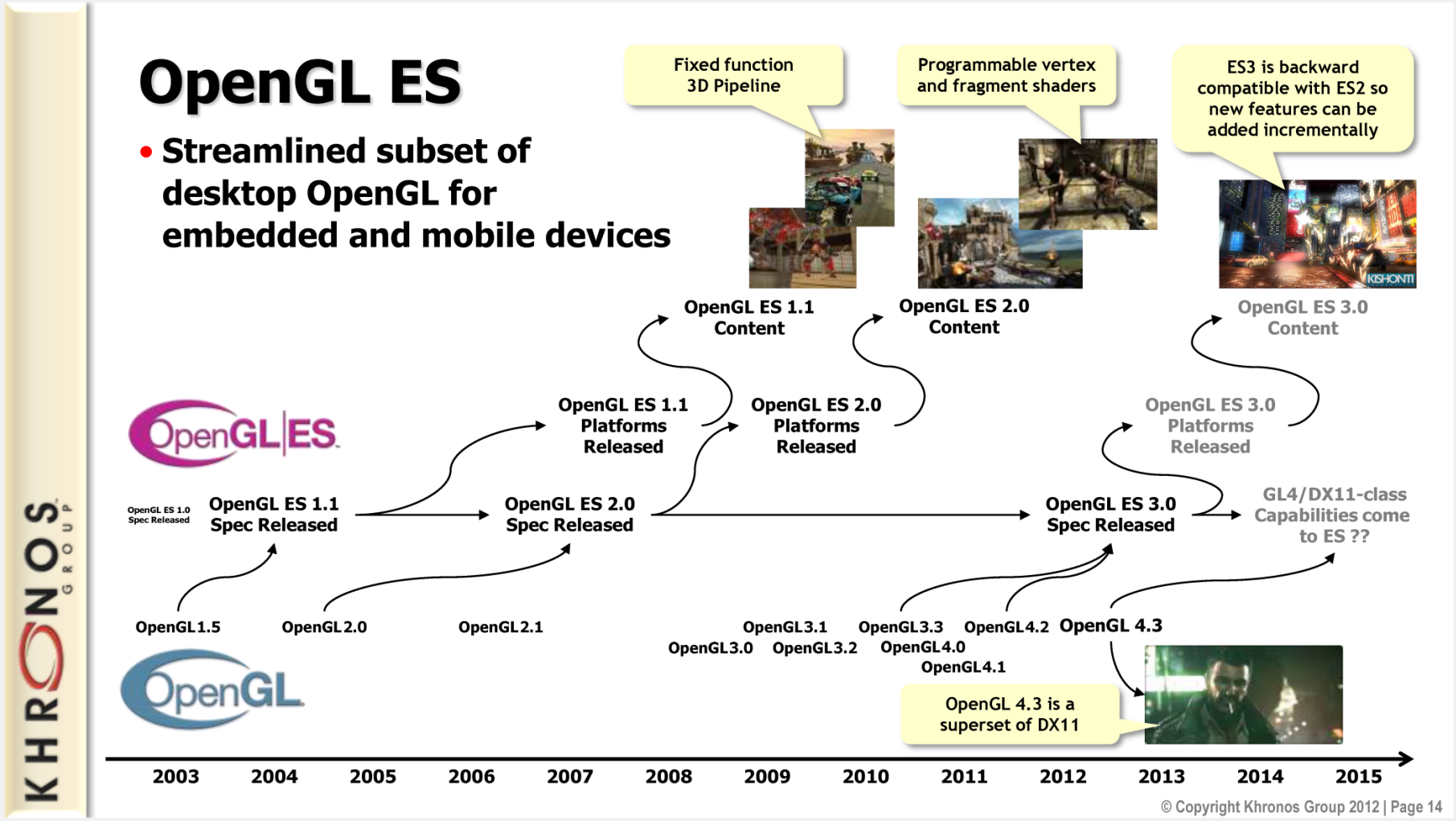


OpenGL ES

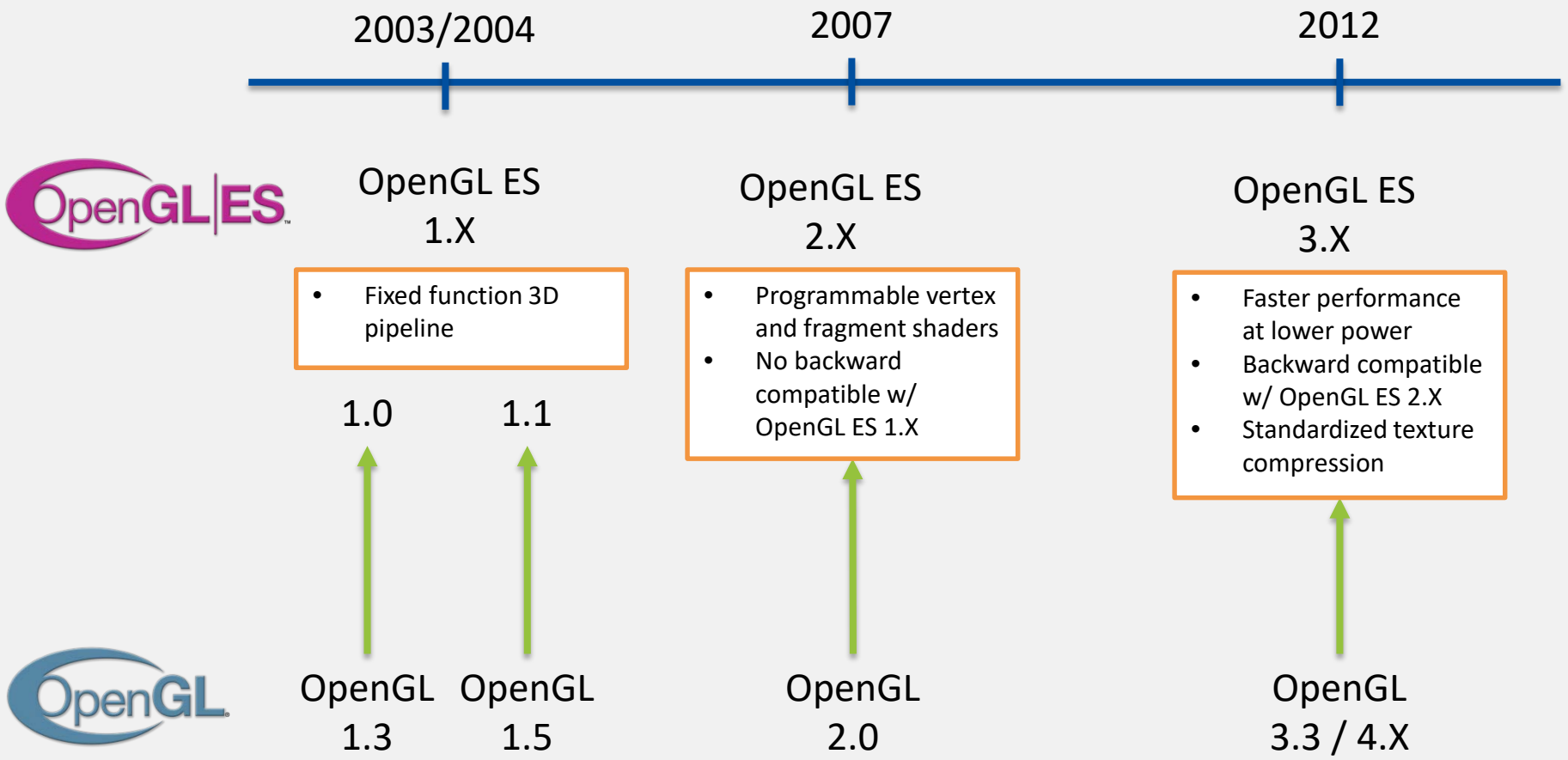
- OpenGL for Embedded Systems
  - A subset of OpenGL for embedded systems
    - Mobile phones, PDAs, video game consoles
  - Royalty-free, cross-platform API
  - Maintained by Khronos Group

- The leading 3D rendering API for mobile and embedded edvices
  - OpenGL ES adopted by every major handset OS
  - OpenGL ES has become the most widely deployed 3D API

History of OpenGL ES



History of OpenGL ES – Summary



Vulkan – New Generation Graphics & Copmute API

- Low-overhead, cross-platform 3D graphics and compute API
  - Drived from & built upon AMD's Mantle
    - Explicit GPU control
    - Multi-threading efficiency
  - Royalty-free, cross-platform API
  - Maintained by Khronos Group

- Next generation GPU APIs
  - Microsoft DirectX 12 – Windows only
  - Apple Metal – Apple only
  - Vulkan – Cross platform (MWC 2016 Demo)

Computer Graphics Systems

Introduction to Computer Graphics

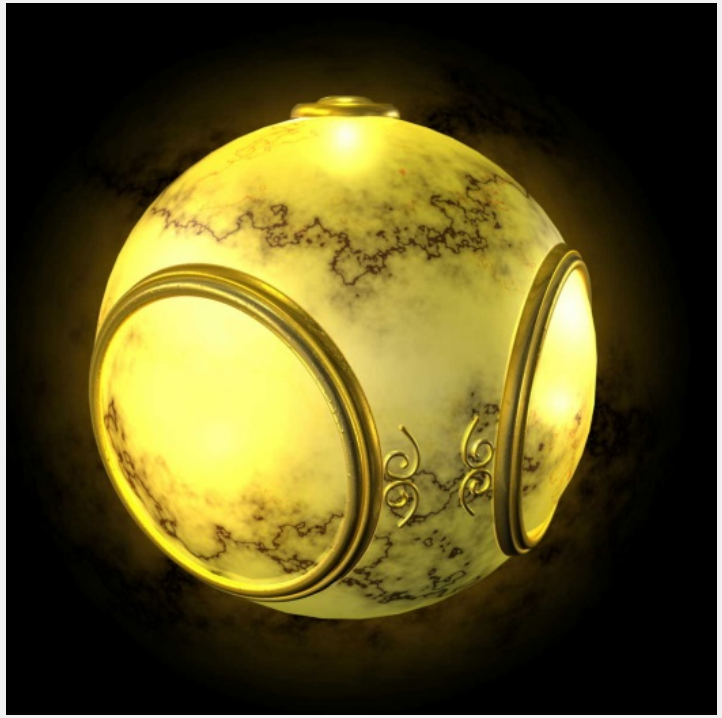
- Computer Graphics is …
  - The representation and manipulation of pictorial data by a computer [from wikipedia.org]

[Toy story – offline graphics]

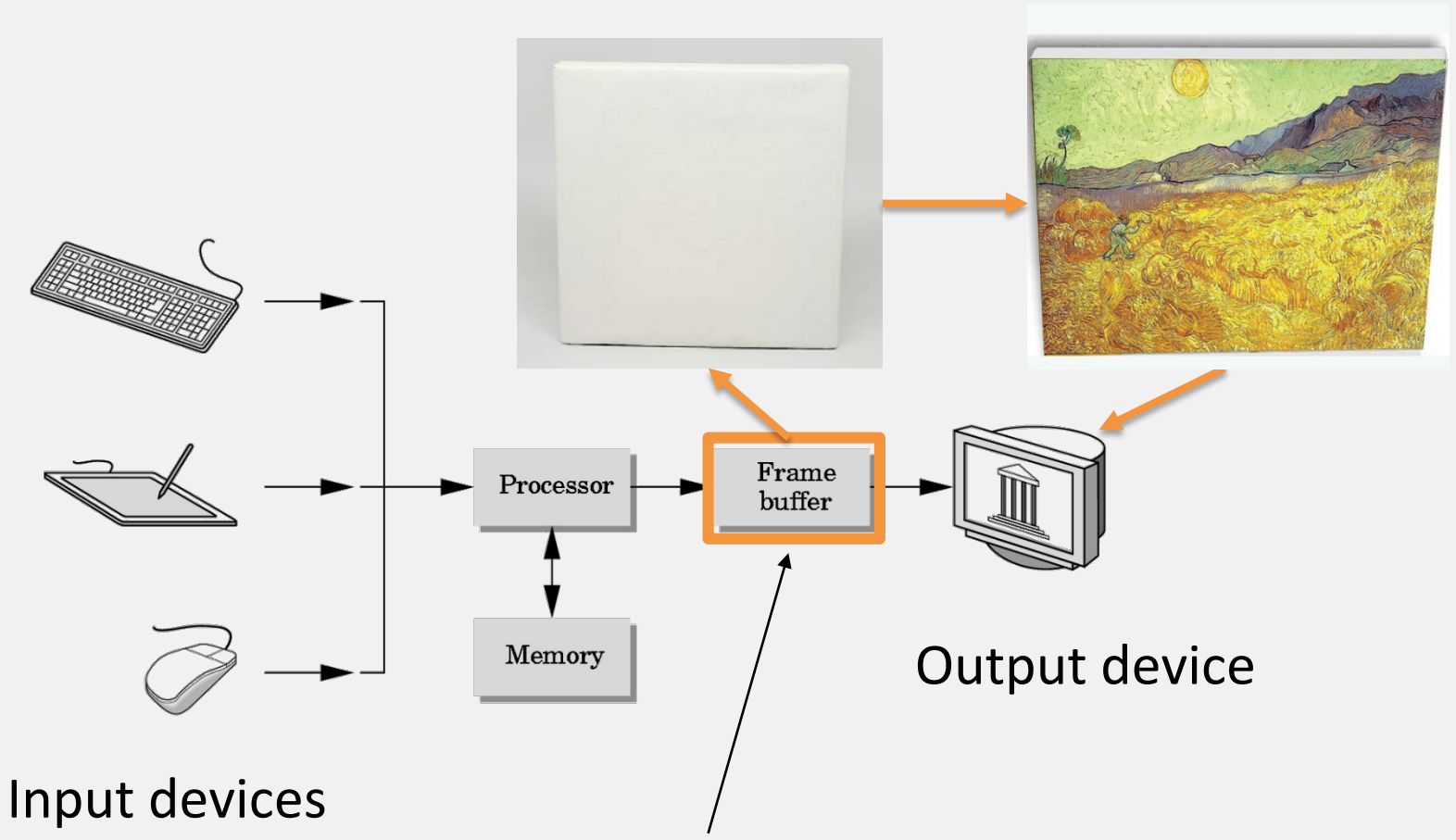
[Skyrim – interactive graphics]

Example

- Where did this image come from?
- What H/W and S/W did we need to produce it?

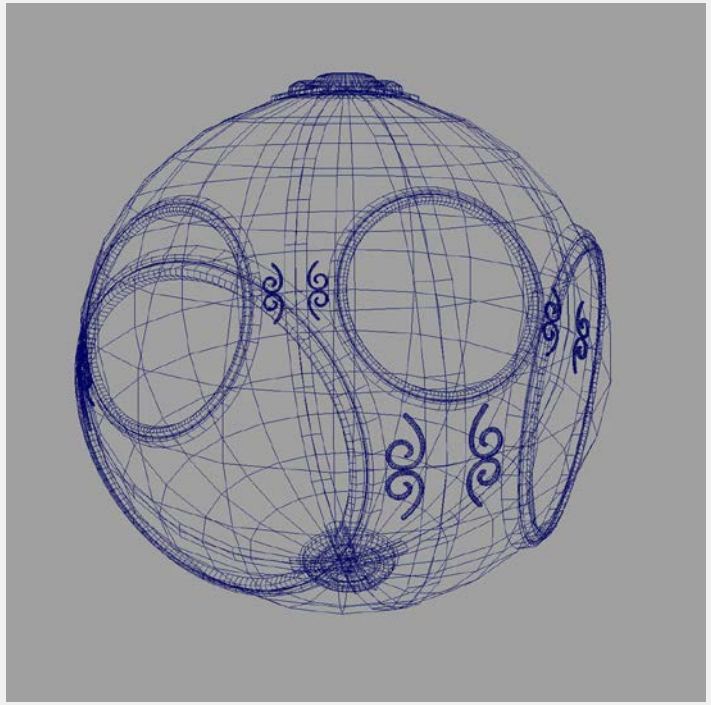


Basic Graphics Systems



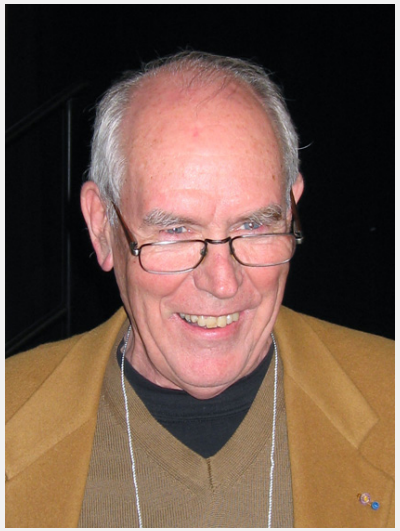
Computer Graphics: 1960-1970

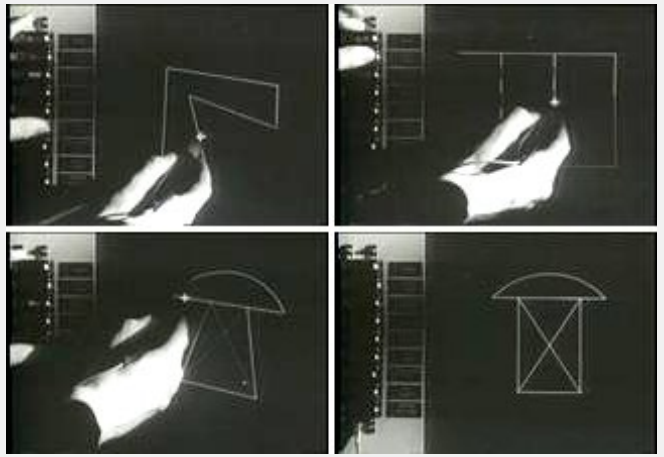
- Wireframe graphics
  - Draw only lines
  - Oscilloscope cathode ray tube (CRT): storage tubes



Sketchpad (1963)

- Ivan Sutherland's PhD thesis at MIT
  - Recognized the potential of man-machine interaction
    - He received the Turning Award in 1988
  - Vector graphics – "line work"

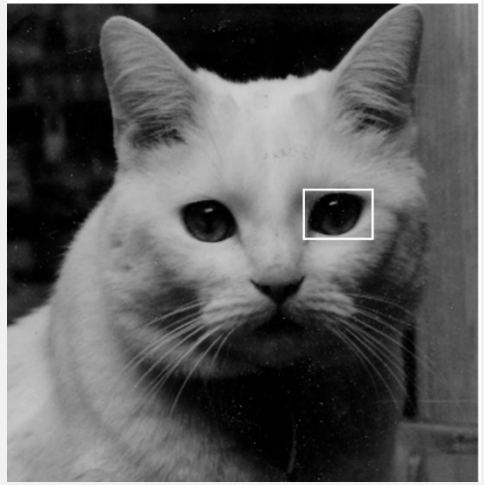


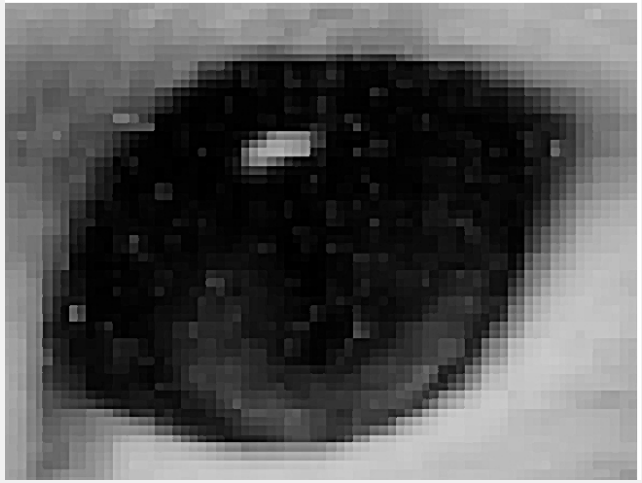


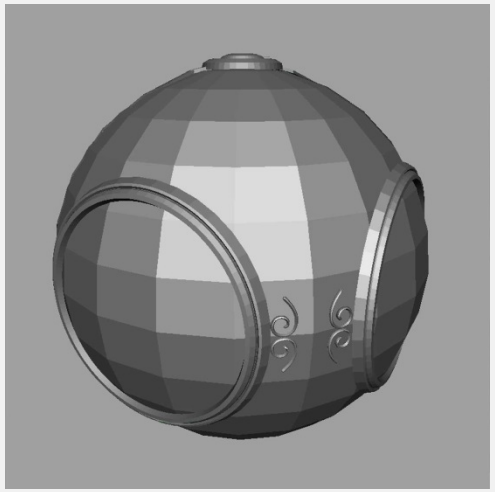
(video, youtube)

Computer Graphics: 1970-1980

- Raster Graphics
  - Image produced as an array (the raster) of picture elements (pixels) in the frame buffer
  - It allows us to go from lines and wire frame images to filled polygons

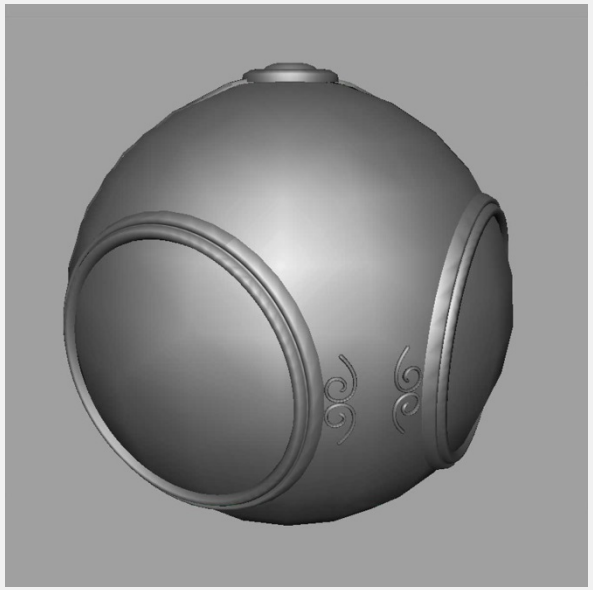




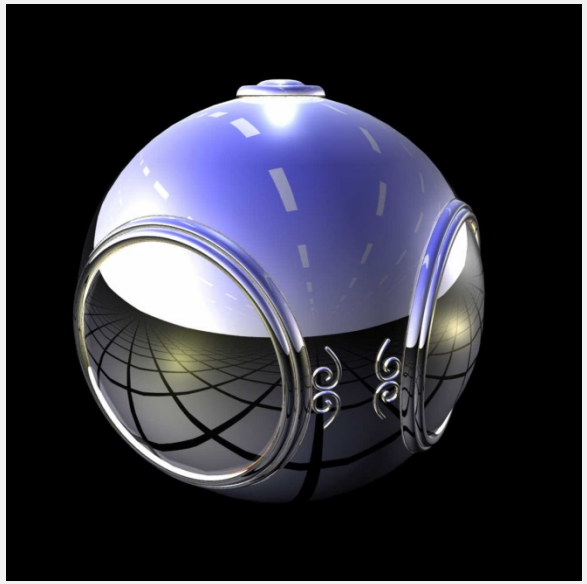


Computer Graphics: 1980-1990

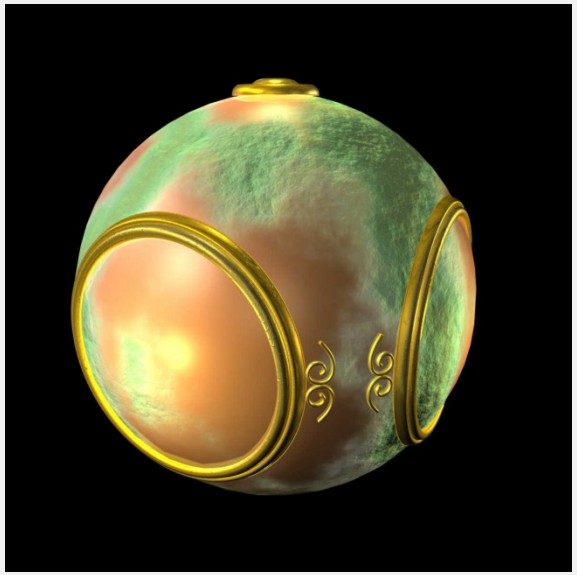
- Realism comes to computer graphics



smooth shading



environment mapping



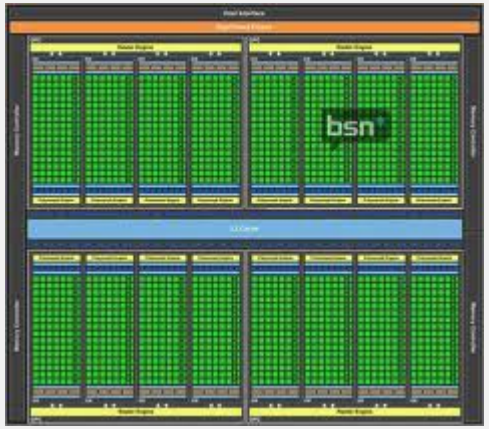
bump mapping

Computer Graphics: 1990-2000

- OpenGL API
- Completely computer-generated feature-length movies (Toy Story) are successful
- New hardware capabilities
  - Texture mapping
  - Blending
  - Accumulation, stencil buffers

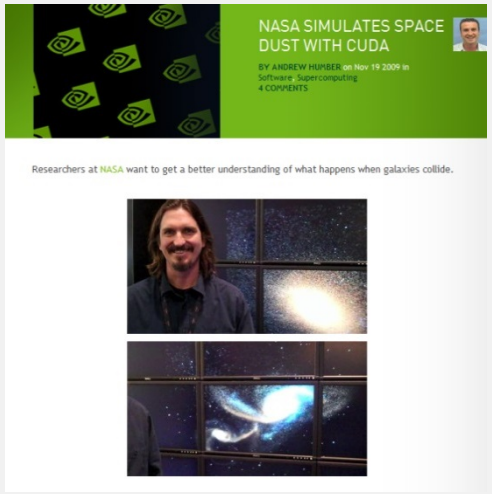
Computer Graphics: 2000-2010

- Photorealism
- Graphics cards for PCs dominate market
  - Nvidia, ATI
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry: Maya, Lightwave
- Programmable pipelines



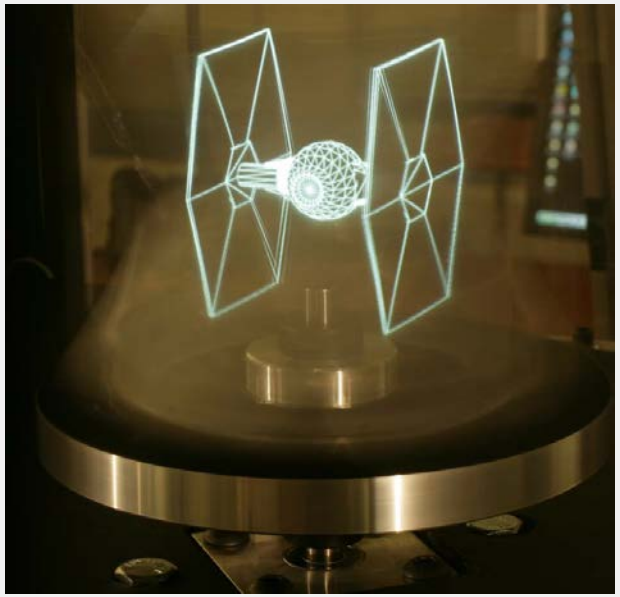
Computer Graphics: 2010-

- Stylized rendering
- Precomputed Radiance Transfer (PRT)
  - Textures become much more important
- Image/Video processing
- General purpose GPU (GPGPU)



What will be the next?

- 3D display system
  - Starwars is becoming a reality
  - http://gl.ict.usc.edu/Research/3DDisplay/
  - Mobile tweak (youtube)



(video, youtube)